

Micromegas readouts for double beta decay searches

S. Cebrián¹, T. Dafni¹, E. Ferrer-Ribas², J. Galán¹, J. A. García¹,
I. Giomataris², H. Gómez¹, D. C. Herrera¹, F.J. Iguez^{1,‡},
I. G. Irastorza^{1,§}, G. Luzón¹, A. Rodríguez¹, L. Seguí¹, A. Tomás¹

¹ Laboratorio de Física Nuclear y Astropartículas, Universidad de Zaragoza, 50009 Zaragoza, Spain

² IRFU, Centre d'Études de Saclay - CEA, 91191 Gif-sur-Yvette, France

E-mail: Igor.Irastorza@cern.ch

Abstract.

Double beta ($\beta\beta$) decay experiments are one of the most active research topics in Neutrino Physics. The measurement of the neutrinoless mode $0\nu\beta\beta$ could give unique information on the neutrino mass scale and nature. The current generation of experiments aims at detector target masses at the 100 kg scale, while the next generation will need to go to the ton scale in order to completely explore the inverse hierarchy models of neutrino mass. Very good energy resolutions and ultra-low background levels are the two main experimental requirements for a successful experiment. The topological information of the $\beta\beta$ events offered by gaseous detectors like gas Time Projection Chambers (TPC) could provide a very powerful tool of signal identification and background rejection. However only recent advances in TPC readouts may assure the competitiveness of a high pressure gas TPCs for $\beta\beta$ searches, especially regarding the required energy resolution. In this paper we present first results on energy resolution with state-of-the-art *microbulk* Micromesh Gas Amplification Structure (Micromegas) using a 5.5 MeV alpha source in high pressure pure xenon. Resolutions down to 2 % FWHM have been achieved for pressures up to 5 bar. These results, together with their recently measured radiopurity, prove that Micromegas readouts are not only a viable option but a very competitive one for $\beta\beta$ searches.

Keywords: Neutrino, Double Beta decay, Neutrino mass, Gas detectors, Micropattern, Micromegas, Energy resolution, Xenon

1. Introduction

After the establishment of neutrino oscillations [1, 2, 3, 4] the determination of the neutrino mass scale is one of the most important goals in modern Neutrino Physics.

[‡] Present address: IRFU, Centre d'Études de Saclay - CEA, 91191 Gif-sur-Yvette, France

[§] Corresponding author

If the neutrino is a Majorana particle, the observation of the neutrinoless double beta decay would provide an estimation of the effective Majorana electron neutrino mass[5]:

$$m_{\beta\beta} \equiv \left| \sum_i U_{ei}^2 m_i \right| \quad i = 1, 2, 3 \quad (1)$$

where U_{ei} are the matrix elements relating the electron neutrino with the three mass-eigenstates and m_i their masses. This information would complement that coming from oscillation experiments, which are only sensitive to the mass differences of the neutrino mass-eigenstates.

The latest generation of $\beta\beta$ experiments [5] are providing sensitivities at the 0.2 – 0.8 eV scale for the effective neutrino mass $m_{\beta\beta}$, obtained with detector masses at the few tens of kg scale. The current generation of setups (being built or commissioned) aims at 100 kg scale detectors, and will provide sensitivities down to 50-100 meV. A forthcoming generation of experiments will need to go to the few tons scale, and reach sensitivities down to 10-20 meV, in order to fully explore the inverse hierarchy models of neutrino masses.

Larger detector masses are not a guarantee of better sensitivity. These series of increasingly large experiments must come with continuous improvements on other experimental parameters [5]. The most important requirements are on the energy resolution and the overall experimental background in the energy region of interest (RoI), around the transition energy of the $\beta\beta$ decay, the $Q_{\beta\beta}$ value. The latter is linked to extreme requirements on radiopurity of the detector components, shielding from external radiation and the availability of signal/background discrimination techniques. The success, and eventual sensitivity, of next generation experiments will depend on the successful achievement of these requirements, rather than on the plain construction of a large detector.

In general, for a next generation $\beta\beta$ experiment of about 100 kg of target mass, background levels below $\sim 10^{-3}$ c/keV/kg/year at the $Q_{\beta\beta}$ will be needed in order to achieve its goals in a few years data taking campaign. For a detector of a few tons to explore the inverse hierarchy region a background level down to $\sim 10^{-5}$ c/keV/kg/year could be needed. On the other hand, the requirement on energy resolution is partially related with the final achieved background level, as it will eventually define the size of the RoI and therefore the background in it. However, the need to separate the tail of the $2\nu\beta\beta$ distribution from the $0\nu\beta\beta$ peak, which otherwise would account for an irreducible background for the latter, sets an upper bound on the energy resolution of an experiment which depends on the intensity of the $2\nu\beta\beta$ signal. As an example, for ^{136}Xe , this argument sets a maximum accepted energy resolution of 4.5% FWHM for a 100 kg experiment, and a 2.5% for a one ton experiment [5] ||.

|| These values are inferred using the current limit on the $2\nu\beta\beta$ in ^{136}Xe . Since for this isotope this decay mode has not yet been observed, the quoted values could be larger

Several detection techniques are being explored in the current generation of experiments, many of them complementary. All of them have to rely on extreme radiopurity constraints for the innermost detector components as well as passive and active shielding against external radiation in order to achieve the required background level. In fact, a large fraction of the experimental effort of these experiments is devoted to the control and improvement of these experimental aspects. Whether this effort will continue yielding even lower levels of background, as needed for the next generation of experiments, is something uncertain. Regarding energy resolution, techniques involving semiconductors or bolometers offer energy resolutions well better than the minimum needed, but other techniques like scintillators or tracko-calorimeters are already at the limit set by the previously mentioned argument for 100 kg experiments, and therefore their extension for larger masses will be difficult.

The use of gas TPCs as calorimeters in the double beta decay search of ^{136}Xe has only recently been considered competitive. The Gothard TPC [6] in the 90's represented a pioneering such use, although discontinued until now due to drawbacks of the technique, like the modest energy resolution achievable. It however demonstrated the potential of a gaseous TPC to powerfully utilize the rich topological signature of $0\nu\beta\beta$ events in the gas, with the characteristic two blob topology, to further reduce background.

Since a few years several novel (or recovered) concepts and considerations regarding the readout of gas TPCs are being put forward that promise to overcome the limitations of conventional TPCs and hence the prejudices against their use in $\beta\beta$ searches. The negative ion TPC or the readout of the electroluminescence signal [7] on one side, or the appearance and consolidation of novel charge readout planes based on micropattern techniques (like the Micromesh Gas Structure – Micromegas –, here considered), with improved energy resolution, homogeneity, stability and scaling-up capabilities, on the other, are key elements in these new TPC concepts. Motivated by these, at least two collaborations (NEXT[8] and EXO[9]) are proposing the use of gas TPCs for $\beta\beta$ research of ^{136}Xe and contemplate active work of development and prototyping.

The present research is focused on the use of Micromegas planes as the readout of a large gaseous TPC for the $\beta\beta$ research of ^{136}Xe . This includes primarily the answer to the question of whether Micromegas planes can operate satisfactorily in high pressure pure Xenon, i.e., with sufficient gain and keeping the good time stability and spatial homogeneity shown in other applications (usually in Argon-based mixtures at atmospheric pressure), and, more specifically, whether sufficiently good energy resolutions for $\beta\beta$ are achieved at the $Q_{\beta\beta}$ energy. Operation in pure Xenon is required due to the fact that a competitive $\beta\beta$ TPC will need to determine the absolute position of the event along the z direction (i.e. along the drift direction), which is obtained by measuring the absolute time of interaction, or t_0 , given by the primary scintillation of the Xe. The use of an additive to the xenon (quencher gas) is therefore only allowed if it is transparent to the

scintillation signal. An scenario with such a quencher is an interesting possibility which we are also investigating. However, in the present paper we are focused on the possibility of operating Micromegas in pure Xenon.

In addition to the previous issues, it is also necessary to study the radiopurity of Micromegas planes in order to know its impact on the backgrounds, and whether it is tolerable in the extremely radiopure environment of the inside of a $\beta\beta$ detector. First results along this line [10] seem to point to the fact that state-of-the-art *microbulk* Micromegas are indeed very radiopure objects, and are very much suited for low background applications. Finally, other less fundamental issues must also be studied, to properly assess the feasibility of Micromegas as a Xe $\beta\beta$ TPC, such as possible outgassing and therefore contamination of the pure Xenon by the Micromegas materials, or the technical issue of extracting all pixel signals out of the high pressure vessel, via very leak-tight, low outgassing, radiopure, high channel density feedthroughs. Although important, none of these issues appear to be of fundamental nature and will not be treated in this paper, which is focused on the primary question addressed before: the operation of Micromegas readouts in high pressure pure Xenon and the achievable energy resolution.

Therefore, the present paper gathers the first successful results of operation of *microbulk* Micromegas planes in pure Xenon at high pressure (up to 5 bar), including measurements of the energy resolution at high energy using the 5.5 MeV alpha peak of an ^{241}Am source. It constitutes an experimental demonstration of the possibility of using Micromegas planes in a Xenon gas TPC for the search of $\beta\beta$ with competitive prospects. In section 2 a brief description of Micromegas is presented, including a brief digression on the issue of energy resolution in a charge amplification readout. In section 3 the experimental setup built specifically for the present measurements is described in some detail. In section 4, we present the methodology followed, the measurements performed and the main results obtained with pure xenon. We finish with the conclusions together with our prospects and future plans in section 5.

2. Energy resolution in Micromegas readouts

The energy resolution in gaseous proportional counters (and by extension in gaseous TPCs with electron avalanche readouts) depends on many factors. Some of them can be considered non fundamental and can in principle be overcome (although with difficulty in practice). Examples of these are non-uniformity of readout planes, problems of equalization of multiple channels, ballistic deficit, attachment to electronegative impurities of the gas or time dependencies. The only truly fundamental effects limiting the energy resolution are the fluctuations occurring in the number of primary electron-ion pairs produced by the ionizing particle (and determined by the Fano factor) as well as the fluctuations in the number of secondary electrons produced in the avalanche initiated by

each primary electron.

The Micromegas [11, 12] readouts make use of a metallic micromesh suspended over an (usually pixellised) anode plane by means of insulator pillars, defining an amplification gap of the order of 25 to 150 μm . Electrons drifting towards the readout, go through the micromesh holes and trigger an avalanche inside the gap, inducing detectable signals both in the anode pixels and in the mesh. It is known [13] that the way the amplification develops in a Micromegas gap is such that its gain G is less dependent on geometrical factors (the gap size) or environmental ones (like the temperature or pressure of the gas) than conventional multiwire planes or other types of micropattern detectors based on charge amplification. This fact allows in general for higher time stability and spatial homogeneity in the response of Micromegas, reducing the importance of some of the non-fundamental factors mentioned above affecting the energy resolution. In addition, the amplification in the Micromegas gap has less inherent statistical fluctuations than that of multiwire proportional chambers (MWPCs), due to the faster transition from the drift field to the amplification field provided by the micromesh [14].

The practical realization and operation of Micromegas detectors have been extremely facilitated by the development of fabrication processes which yield an all-in-one readout, in contrast to "classical" first generation Micromegas, for which the mesh was mechanically mounted on top of the pixelised anode. Nowadays most of the realizations of the Micromegas concept for applications in particle, nuclear and astroparticle physics, follow the so-called *bulk*-Micromegas type of fabrication method or, more recently, *microbulk*-Micromegas.

While the bulk Micromegas [12] uses a photo resistive film to integrate the mesh (usually a commercial woven mesh) and anode, being already a mature and robust manufacturing process, the microbulk Micromegas is a more recent development [15]. It allows to provide, like the bulk, all-in-one readouts but out of double-clad kapton foils. The mesh is etched out of one of the copper layers of the foil, and the Micromegas gap is created by removing part of the kapton by means of appropriate chemical baths and photolithographic techniques. Although the fabrication technique is still under development, the resulting readouts have very appealing features, outperforming the bulk in several aspects. The mechanical homogeneity of the gap and mesh geometry is superior, and in fact these Micromegas have achieved the best energy resolutions among MPGDs with charge amplification. Because of this, time stability of microbulk is expected to be also better than bulk. On the other hand, they are less robust than the bulk and for the moment the maximum size of single readouts are of only 30 cm (the limitation coming from equipment limitation and not fundamental). This type of readouts are being used in the CAST experiment [15].

In addition, the readout can be made extremely light and most of the raw material is kapton and copper, two of the materials known to be (or to achieve) the best levels of

radiopurity [16]. Indeed, the first radiopurity study of Micromegas [10] shows that current microbulk readouts contain radioactivity levels at least as low as $57 \pm 25 \mu\text{Bq}/\text{cm}^2$ for ^{40}K , $26 \pm 14 \mu\text{Bq}/\text{cm}^2$ for ^{238}U , $< 13.9 \mu\text{Bq}/\text{cm}^2$ for ^{235}U and $< 9.3 \mu\text{Bq}/\text{cm}^2$ for ^{232}Th .

Experimentally, resolutions of 11% FWHM for the 5.9 keV ^{55}Fe peak, like the one shown in Fig. 1 are routinely achieved by the current microbulk readouts in Argon-isobutane mixtures. Assuming a square root of energy dependency, this value would point to energy resolutions of less than 1% at the MeV scale, fulfilling by far the requirements for double beta decay applications. An experimental confirmation of this is difficult due to the need of confining high energy events in the detection volume. In our previous work [17], we used an ^{241}Am alpha source to measure energy resolutions of microbulk readouts at high energies, obtaining values down to 1.8% FWHM for the 5.5 MeV alpha peak at pressures from 2 to 4 bar of argon-5% isobutane mixtures. Furthermore, the asymmetry of the peak pointed to resolutions down to 0.7% FWHM, as shown in Fig. 2.

The present paper aims at extending these results for the case of pure Xenon. Charge amplification in pure noble gases is problematic due to the rapid photon-driven expansion of the avalanche, which makes the detector quickly depart from the proportional amplification regime into the Geiger regime. This effect is usually avoided with the use of gas quenchers, but as argued before, this may not be possible in a Xe TPC with t_0 measurement based on the primary scintillation. Microbulk detectors can be built in such a way that the kapton in between mesh and anode is only removed slightly beyond the cylindrical area below every mesh hole. The avalanche is thus confined in a kapton cell, preventing the photons from expanding the avalanche far away. We speculate that this effect could work as a kind of quencher of the avalanche, and account for the modest gains indeed observed [17]. This adds interest to the test of these readouts in pure noble gases. It is a fact that needs investigation by itself, and will not be explored in this paper, which is just devoted to measure the energy resolution in pure Xenon.

In [17] we operated microbulks in pure Xenon, obtaining promising results, although the measurements were limited by attachment present in the system available for that work. Here a completely new setup has been built with improved tightness and outgassing conditions, in order to guarantee the purity of the Xenon.

3. Experimental setup

The experimental setup was built purposely for these measurements. Its overall scheme is shown in Fig. 3, and consists of a high pressure vessel and a high purity gas system for recirculation and purification. The gas system includes a gas mixer, a turbomolecular pump, a set of gas filters, several vacuum and high pressure gauges, a high pressure recirculation pump, a back-pressure controller, a flow meter and an exhaust line with anti-return valve.

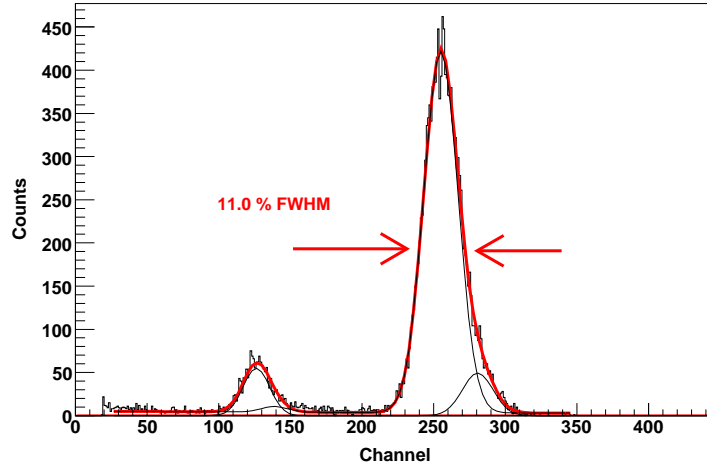


Figure 1. Typical spectrum of ^{55}Fe with a microbulk Micromegas in an argon-isobutane mixture. The red line is the result of a fit to 4 gaussians, while the thin black lines are the 4 gaussians separately, corresponding to the two x-ray emission lines of ^{55}Fe of 5.9 and 6.5 keV, and their corresponding escape peaks in argon.

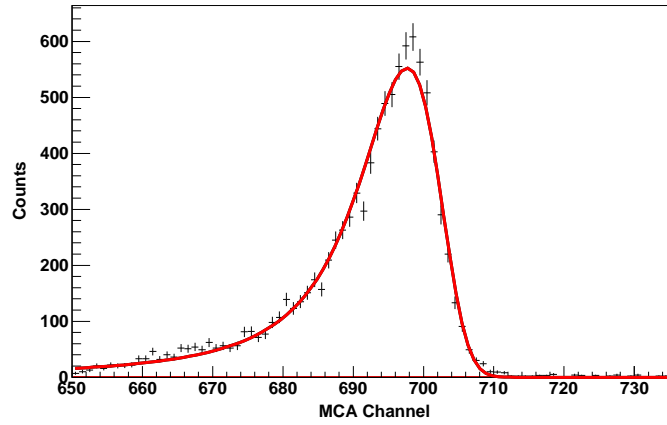


Figure 2. Example of an alpha peak measured in [17], with the fit to a Landau function convoluted with a gaussian. The best fit values for the FWHM of the gaussian component is 0.7%.

The vessel (shown in Fig. 4) is made of stainless steel and fulfills both ultra-high vacuum (UHV) and high pressure (up to 15 bar) requirements. Inside it has a cylindrical shape, with 10 cm height and an internal diameter of 16 cm. Various SHV and BNC vacuum feed-throughs allows the electrical connections for both the signals and voltages of the detector. They are all implemented in CF flanges with copper joints. Specific tests were done to assure their suitability for high pressures. A larger 15 cm CF flange allows access to implement the drift structure and the readout inside the vessel. Outside, the

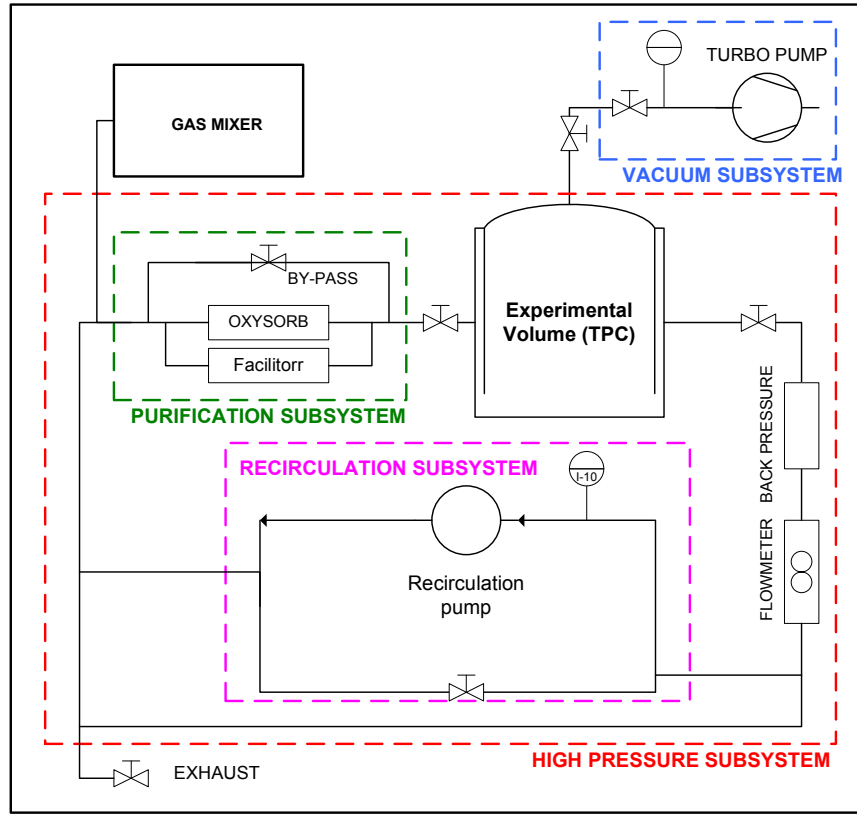


Figure 3. Sketch of the gas filtering and recirculation setup used for measurements .

vessel is equipped with a heat insulator blanket and four resistors in order to bake out the system up to 110°C .

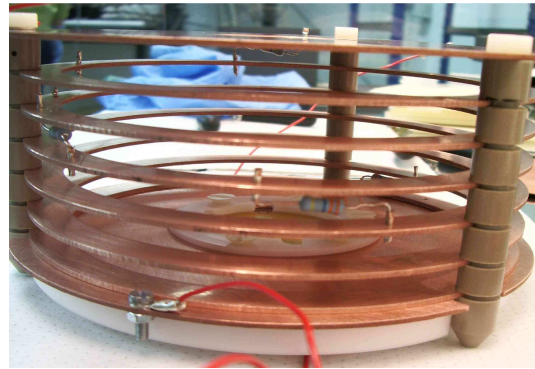
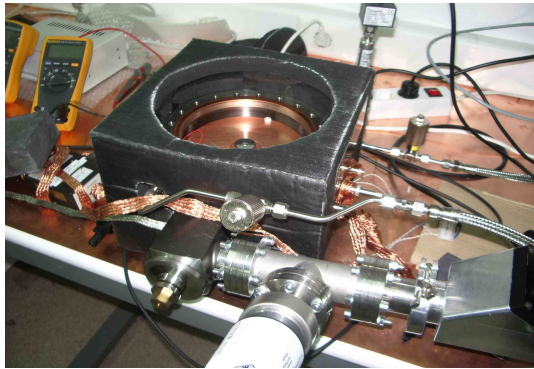


Figure 4. (a) Picture of the high pressure vessel, opened at the top endcap. (b) Picture of the drift and field cage structure over the Micromegas readout.

As shown in the sketch of Fig. 3, the vessel can be evacuated by means of the

turbo pump, through one of the CF-40 outlets. The "vacuum" part of the system (turbo pump and vacuum gauges) is isolated from the "high pressure" part by the all-metal valve and another vacuum valve in series. Gas can be introduced into the vessel through the gas inlet. Gas mixtures can be produced with the gas mixer, which is composed by 3 independent gas lines with Bronkhorst mass flow controllers able to work at high pressure (10 bar). Preliminary results used mixtures of argon and isobutane, although in the present paper all results are obtained in pure Xe. The gas is passed through a MESSER oxysorb filter before entering the system. Once inside the vessel, the gas can be made to recirculate along a closed loop by means of a KNF membrane pump, and force it to continuously pass through a filter (alternatively a MESSER oxisorb or a SAES FaciliTorr). The recirculation flow is measured by a high precision flowmeter and the pressure in the vessel is controlled with a back-pressure controller.

The present system supposes a clear improvement in terms of gas purity (initial level of vacuum, outgassing rate, capability of filtering impurities) with respect to our previous work in [17]. A technical paper is under preparation to describe in detail the system, the tests performed to characterize, and different measurements performed other than the ones of interest for the present paper [18].

The high pressure vessel was equipped with a state-of-the-art 3.5 cm diameter circular *microbulk* Micromegas readout of 50 μm gap, with a single non-segmented anode covering all this area. The readout laid on a metallic support of 10 cm diameter. Apart from mechanically supporting the Micromegas readout, it aims at extending the equipotential surface defined by the Micromegas mesh. On top of this support the field cage preserves a good shape of the drift electric field (i.e. drift lines perpendicular to the Micromegas plane) all along the conversion volume which projects onto the Micromegas surface. The field cage includes a circular cathode 6 cm above the Micromegas and several shaping rings (one per cm) at intermediate voltages set by a resistor chain. The drift cathode was prepared to hold the Americium source in its center.

The electrical connections were made in such a way that we could power independently the drift cathode, the Micromegas mesh and the supporting piece. Although, as explained before, the voltage of the supporting piece is usually set the same as the one of the mesh in order to preserve the drift field. The signal was read out from the Micromegas mesh using a CANBERRA 2004 preamplifier, whose output was fed into an ORTEC VT120 amplifier/shaper and subsequently into a multichannel analyzer AMPTEK MCA-8000A for spectra building. Alternatively, the output of the preamplifier was digitized directly by a Tektronix TDS5054B oscilloscope and saved into disk for further offline inspection.

4. Measurements and results

The system was cleaned before every measurement by pumping it down to pressures below 10^{-6} mbar. The purity of the Xe gas used in the measurements here presented was of grade 6.0 (99.9999%) provided by Praxair. The actual purity of the gas during the measurements, determined also by the outgassing of materials inside the vessel and the effect of the filters was proven to be sufficient as no evidence of attachment was seen with moderate drift fields.

The ^{241}Am source used for the measurements consisted on a metallic circular substrate of 8 mm diameter with the Americium deposited on its center, in an approximate circular region of about 5 mm diameter. The source is not sealed, that is, no material is present on top of the americium that could stop the alphas. It was installed inside the vessel, attached to the center of the drift cathode, and in electrical contact with it, facing the center of the Micromegas readout. The intensity of the source was ~ 10 kBq.

All data here presented were taken in short runs for which sealed-mode operation was sufficient, i. e. the vessel was filled up to the desired pressure with the output outlet closed, and the gas remained static in the vessel during the run (only one pass through the input filter). In this way we operated the system at four different gas pressures: 2, 3, 4 and 5 bar. The first one of 2 bar was the minimum pressure where the projection of alpha tracks on the readout is fully contained. The maximum of 5 bar was a limit imposed indirectly by the relatively intense source available for the tests. Although higher gains were possible with the source collimated (and therefore less intense) [17], the present results (taken necessarily with the source uncollimated) were limited to gains of only about 10-20, due to the amount of total charge density generated in the Micromegas gap (related with the Raether limit). Due to this limitation, at pressures above 5 bar, the minimum drift fields needed to overcome attachment corresponded to field ratios out of the plateau of Fig. 5, suffering from loss of electron transmission through the mesh. Current work to extend the present results to higher pressures is ongoing, including the use of a weaker alpha source, and the use of the recirculation system to reduce the effects of attachment at low fields.

For each of the indicated pressures, the data-taking includes the systematic variation of the mesh and drift voltages. The mesh voltage is typically varied in the range from -100 V to -600 V (the Micromegas anode is kept at ground), depending on pressure, corresponding to amplification fields from 40 to 120 kV/cm. The drift voltage is varied from -250 V up to about -4000 V corresponding to drift fields from 15 V/cm to 770 V/cm. For each case, quick spectra with the MCA are registered, as well as a number of (at least 5×10^4) pulse waveforms with the oscilloscope. These pulse shapes are analysed (PSA) offline, to extract pulse characteristics like risetime and amplitude. Spectra shown later on are always based on the pulses amplitude given by the PSA.

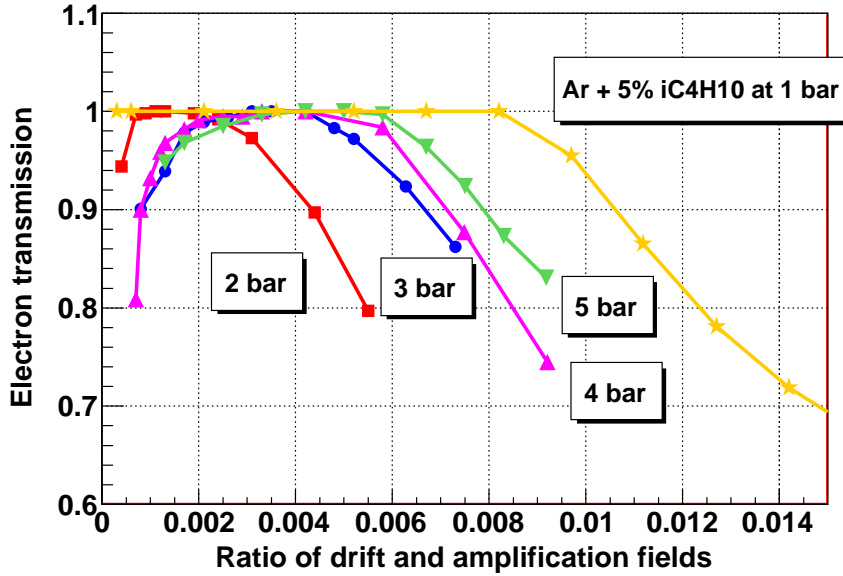


Figure 5. Dependence of the alpha peak position on the ratio of drift and amplification fields (*electron transmission curve*) at 2 (red squares), 3 (blue circles), 4 (magenta triangles) and 5 bar (inverted green triangles). As a comparison, the same curve for Ar + 5% iC₄H₁₀ at 1 bar (yellow stars) is included. Values are normalized to the maximum of each series.

The evolution of the peak position versus the drift/amplification field ratio gives the electron transmission curve, shown in Fig. 5 for each of the pure Xe pressures, and compared with a typical such curve taken in argon-isobutane at atmospheric pressure. The characteristic plateau of this curve, which usually extends to a field ratio of ~ 0.01 for this type of readout [17], is considerably shorter for pure Xe, something that can be qualitatively explained by the larger electron diffusion in pure Xe [19]. The shortening of the plateau at low drift fields for the highest pressures is due to attachment.

Pressure (bar)	Energy resolution (% FWHM)	
	raw data	risetime cut
2.0	3.4	2.2
3.0	2.7	2.2
4.0	2.5	1.8
5.0	3.2	2.4

Table 1. Energy resolutions measured (both from the raw data and the data after the selection on risetimes explained in the text) in pure xenon for pressures between 2 and 5 bar.

The energy resolution of the alpha peak is extracted from the raw spectra by means of gaussian fits, like the ones shown in Fig. 6. The values obtained are reproduced in all over a range of values for the drift and amplification fields roughly corresponding to the plateaus of Fig. 5, and are listed in table 1. In general, energy resolutions at the 3 % FWHM level have been achieved, with a best value of 2.5 % FWHM for the 4 bar data series. These results improve considerably our previous preliminary results [17], something that we attribute to the improved gas purity conditions in our current setup.

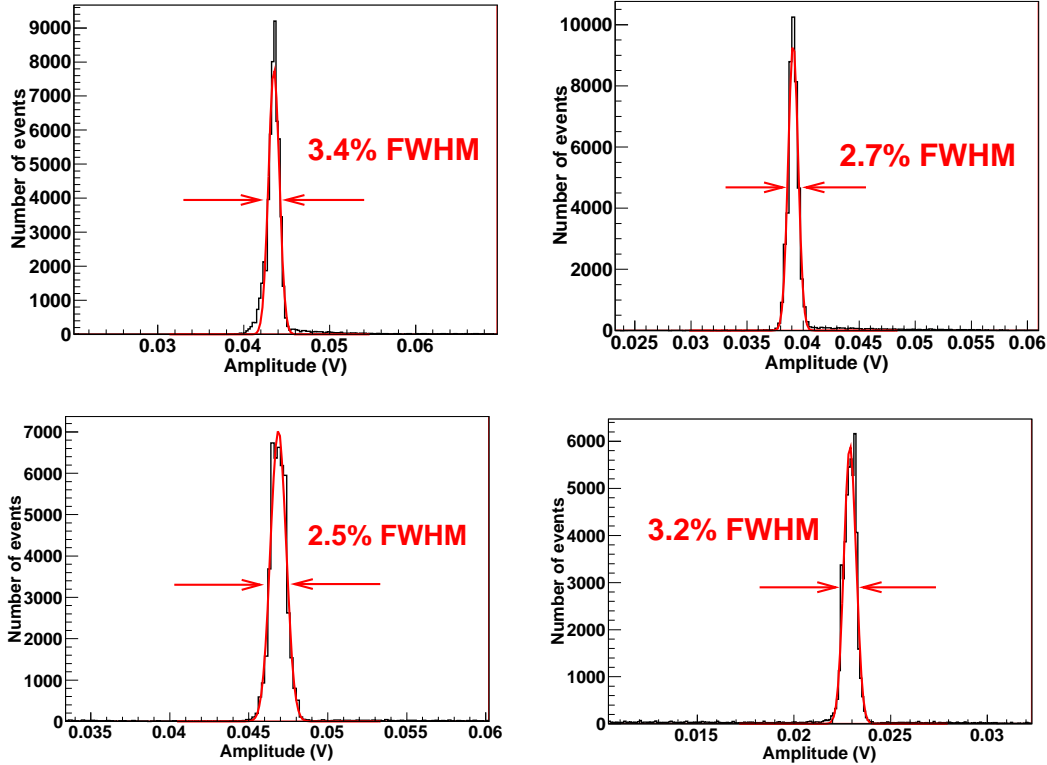


Figure 6. Energy spectra of the ^{241}Am alpha peak measured in the setup at 2 (top left), 3 (top right), 4 (bottom left) and 5 bar (bottom right). The red line and the value for the energy resolution are the result of the fit to a Gaussian function.

By inspection of amplitude-risetime plots like the one shown in Fig. 7, we observe, unlike in [17], no effect of attachment (with the possible exception of the 5 bar series, in which a slight correlation is present at low fields). There is, however, a remaining correlation not linked with attachment, and affecting the events with the shortest risetime, which show amplitudes slightly below the center of the population (clearly seen in Fig. 7). These events correspond to alpha tracks with the highest angle with the vertical, i. e. alpha tracks almost horizontal and therefore very close to the cathode in all their trajectory. It could be that part of the ionization of those events is deposited in the source

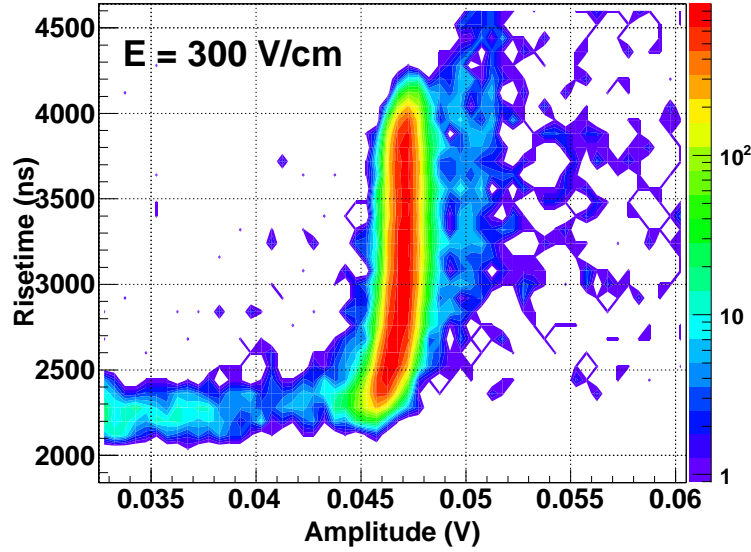


Figure 7. Risettime-amplitude distributions for pure xenon at 4 bar obtained at drift field of 300 V/cm. The gradation of color indicates the number of events in logarithmic scale.

itself, scattered back to the cathode, or in any case lost by some edge effect induced by the proximity of the cathode. The contribution of these events to the energy resolution can be removed by performing selection of events by risetime before the gaussian fit. In this way, the values of the energy resolution obtained, listed in the last column of table 1, improve to values around 2% FWHM, with a best value of 1.8% FWHM for the 4 bar series.

The extrapolation of this result to the $Q_{\beta\beta}$ energy of the $\beta\beta$ event depends on whether alphas suffer from any ionization quenching with respect to electrons. The authors of [6] report a factor as large as 6.5 in the relative ionization of electrons with respect to alphas in a xenon- CF_4 mixture, although we did not measure any difference in our study in argon [17]. If the value of 6.5 is true for pure Xe, our result would point to energy resolution down to 1% or below for a $Q_{\beta\beta}$ electron energy. In the most conservative side, if no difference in ionization yield is assumed between alphas and electrons, and the resolution just scales with the square root of energy (disregarding constant energy-independent additive term to energy resolution), the expected value would be around 3% FWHM. Any intermediate situation is possible. In any case, the present result is already sufficiently good to qualify Micromegas readouts for $0\nu\beta\beta$ experiments using the high pressure gas Xe TPC technique.

5. Conclusions and prospects

We have presented measurements of energy resolution of 5.5 MeV ^{241}Am alphas, with a Micromegas microbulk readout at high pressure pure xenon, using a new experimental setup built for this work. Energy resolutions around 3 % FWHM are obtained for pressures of 2 to 5 bar, being the best one of 2.5 % for the 4 bar case. Using a selection of events based on risetime we are able to remove edge effects and these values improve to $\sim 2\%$ FWHM (being the best value 1.8% FWHM for the 4 bar case). This is, to our knowledge, the best energy resolution for alpha particles obtained with gas amplification in pure Xenon, and in particular better than the requirements set by [5] for double beta decay searches. This result therefore experimentally demonstrates our claim that state-of-the-art Micromegas of the microbulk type are a feasible and competitive option for a Xe TPC for double beta decay.

We are currently focused on extending the present results to higher pressures, up to 10 bar. As future steps, we plan to test microbulk readouts with reduced amplification gap, which should provide better performance at higher pressures [13], as well as to explore the effect of possible quenchers in Xenon on the energy resolution. Although the work here presented represents a basic step forward in demonstrating the absence of fundamental problems for Micromegas operation in pure Xe, more work is needed to deal with also important issues like long term stability, measurement with actual electron tracks, use of a pixelised readout to do tracking, and simultaneous measurement of energy and tracking. Work is ongoing also in this directions, under the framework of the NEXT collaboration. We are setting up right now a relatively large Micromegas TPC of dimensions 30 cm diameter and 35 cm drift of fiducial volume, able to hold ~ 1 kg of Xe at 10 bar. In this fiducial volume high energy electron tracks are fully contained, and the previous issues can be thus studied.

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